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The observational comparison analysis between the SEP events on 2000 July 14 and 2003 October 28

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The comparison analysis between the SEP events taken place on 2000 July 14 and 2003 October 28 is made. The peak flux of energy greater than 10MeV and 30MeV for the Bastille event is higher than those for the 2003 October 28 event in interplanetary space meaning that the number of the seed particles which can be accelerated to energy greater than 10MeV and 30MeV by CME-driven shock on 2000 July 14 are much more than that of the seed particles on 2003 October 28. The peak flux 155pfu for energy greater than 100MeV on 2003 October 28 is much lower than the peak flux 355pfu for energy greater than 100MeV on 2000 July 14. This means that the number of the seed particles can be accelerated to the energy greater than 100MeV for Bastille event are much more than that of the seed particles for 2003 October 28 event. The peak flux of the solar proton event (SPE) at geostationary orbit for 2003 October 28 SEP event is higher than that for 2000 July 14 SEP event reaveling that the intensity of a SPE not only depends on the intensity of solar energetic particle in interplanetary space but also depends on the speed of associated CME-driven shock.

1. Introduction

The Space Bastille Day Event was caused by AR9077's a series of solar activities. An X5.7 flare was accompanied by a strong fast halo CME. A very strong SEP event and a very strong magnetic storm was observed. Many papers have been devoted to the study of the event [1～8]. AR10486 produced an X17.2 flare associated with a very strong halo CME on 2003 October 28. The basic point of view for SEP is that the flare accelerates the SEPs in the impulsive event while shock accelerate the SEPs in gradual event [9].Mixed events consisting of bot particles accelerated in the flare and at the shock don't exit (Reames2002) [10]. Both flare and CME-driven shock accelerate SEPs with the only flare or shock accelerates SEP being the limiting cases (Kallenrode 2003)[11]. Cane et al ever studied the two components in SEPs[12], Kahler ever studied factors influencing the intensity of SEP and pointed out that the intensity of the seed particles provided for shock acceleration is very important for the SPE flux [13]. Because the SEP flux used in their study is the energetic protons at stationary orbit with energy greater than 10MeV, so he actually study the correlation between the CME's velocity with the peak flux of solar proton event. Gopalswamy[14~15]point of view is that the the CMEs' interaction is very important for the intensity of SPE. The comparison have been made is really the peak flux of SPE observed at geostationary orbit in the past while the comparison of the intensity of SEP flux for different SEP events in interplanetary space hasn't been made.

The peak flux of SPE for 2003 October 28 SEP event is 29500pfu higher than that for 2000 July 14 SEP event with peak flux 24000pfu. By comparising the peak flux in interplanetary space of the two SEP events, we can easily find that both fluxes for energy greater than 10Mev and 30MeV are higher than those for 2003 October 28 SEP event. We ever pointed out the variation of SEP flux at geostationary orbit can't reflect the real situation in interplanetary space [8]. In this paper we find that the peak flux of SPE not only depends on the intensity of SEP in interplanetary space but also depends on the CME-driven shock's speed and the situation of seed particles in solar wind. The ability of when the shock accelerating the protons to energy greater than 100MeV reached its maximum in the two SEP events is estimated. Finally the number of seed

particles variation with distance from the sun is briefly discussed.

2. Data Analysis

The flare and CME's information are listed in table 1 for 2000 July 14 and 2003 October 28, respectively. Obviously the peak flux for 2003 October 28 SPE is greater than that 2000 July 14 shown in Figure 1[15]. The flux for energy greater than 10MeV and 30MeV for 2000 July 14 and 2003 October 28 observed by ACE satellite are shown in Figure 2. Both SEP counter of ACE satellite for energy greater than 10MeV and 30Mev saturated which means the flux for greater than 10MeV and 30MeV exceeds 10000pfu and 7000pfu[16], respectively at 13:00UT 2000 July 14. The peak flux for energy greater than 10MeV and 30MeV observed by ACE for 2003 October 28 SEP event is 3559pfu and 1445pfu，respectively, which is much lower than that of the Bastille Day SEP event shown in Figure 2. For Bastille Day Event at 10:54UT, 2000 July 14，the CME reached the height 5.41R□[17]. About two hours later the counter on ACE for greater than 10MeV and 30meV saturated reavling that the number of seed particles which can be accelerated to energy greater than 10meV and 30MeV were much enough. For 2003 October 28 SEP event, form the height when CME reached 5.84R□ at 11:30UT to the height when CME reached the height at 15:00UT to three hours later[18]，the seed particles can be accelerated are much less than that in Bastille Day Event. So the level of a flare and the velocity of a shock can't decide the intensity of SEP flux in interplanetary space, the number of seed particles is also a important factor. For 2003 October 28 SEP event, the variation of SEP flux for energy greater than 10MeV and 30Mev is small and the shock's velocity still exceeded 2000km/s[19] when the shock arrived at 1AU, so the number of seed particles in interplanetary was almost constant in interplanetary space. The situation for the 2000 July 14 SEP event was not the same because the SEP flux for energy greater than 10MeV and 30MeV changed greatly in interplanetary space.

Table 1. some information about the flare and CME for 2000 July 14 and 2003 October 28 SEP event

Time	Active Region	Location	Flare	V1	V2	Peak flux of SPE
2000/07/14	9077	N22W07	X5.7	1671km/s	～1100 km/s	24000pfu
2003/10/28	10486	S16E08	X17.2	2429km/s	～2000 km/s	29500pfu

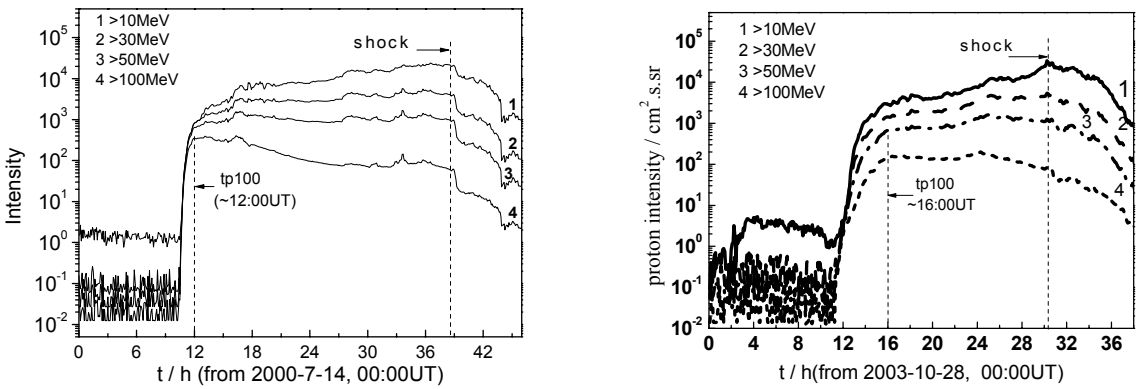

Figure 1. The flux of SPE observed by GOES satellite for 2000 July 14 and 2003 October 28 SEP event

The peak flux of SEP in interplanetary space for Bastille Day Event is higher than that of SEP in interplanetary space for 2003 October 28 event, when shock reached around magnetosphere the SEP flux for energy greater than 10MeV in interplanetary space for Bastille Day Event is still higher than that of 2003 October 28 even, but the situation for peak flux at geostationary orbit is opposite for the two events. We think that the shock's speed for 2003 October 28 event is faster than that for Bastille day Event is one reason. Because the protons with energy around 10MeV and 30MeV can stay at geostationary orbit for some time, the faster the shock speed, the more particles sent to the geostationary orbit and pile there. So the intensity of SEP flux in magnetosphere not only depend on the intensity of SEP flux in interplanetary but also depend on the associated shock speed.

Figure 1 and Figure 2 show that the flux for energy greater than 10MeV and 30MeV in interplanetary space decreases while the the flux for energy greater than 10MeVat geostationary orbit increases for Bastille Day Event. This means that the protons with energy around 10MeV and 30MeV can be quasi-captured at geostationary orbit, so the variation of SEP flux for energy greater than 10MeV and 30MeV can't really reflect the variation of SEP flux in interplanetary space. For the SEP with energy greater than 100MeV, the property in the flux variation is that flux began to decrease after the flux increase a peak value within short time, so the SEP flux for energy greater than 100MeV at geostationary orbit can basically reflect the situation of shock accelerating such energy particles in interplanetary. The SEP flux for energy greater than 100MeV reached a local maximum within a definite time revealing the ability of shock accelerating the such energy particles reached its maximum.. For Bastille Day Event, at around 12:00UT, 2000 July 14, The SEP flux for energy than 100MeV almost reached its maximum. For 2003 October 28 SEP event, at around 16:00UT, 2003 October 28, the SEP flux for energy than 100MeV almost reached its maximum. Based on the variation of CME's speed, we estimate for Bastille Day Event that the ability of shock accelerating SEP of 100MeV reached its maximum when the CME reached about 22.2R□ with SEP flux for energy greater than 100MeV 355pfu. For 2003 October 28 SEP event, we estimate t that the ability of shock accelerating SEP of 100MeV reached its maximum when the CME reached about 61R□ with SEP flux for energy greater than 100MeV 155pfu much lower than that of Bastille Day Event.

The time needed for all energy channel reached their maximum for Bastille Day Event is shorter than those for 2003 October 28 in interplanetary space and with bigger flux value, so there is big difference in the number of seed particles in the distance within 22.2R□ form the sun between the two SEP events.

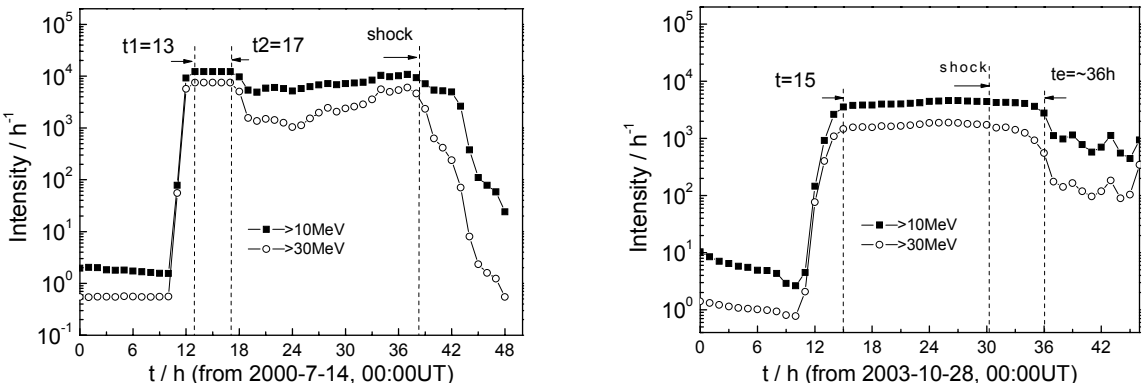

Figure 2. The variation of SEP intensity with time for 2000 July 14 and 2003 October 28 SEP event

3. Summary and Discussion

The peak flux in interplanetary space for energy greater than 10MeV and 30MeV for Bastill day Evevt is

much bigger than those for 2003 October 28. The peak flux of Bastille Day Event observed at geostationary orbit for energy greater than 100MeV is much bigger than that of for 2003 October 28 SEP event. The SEP flux for energy greater than 10MeV and 30MeV at geostationary orbit can't reflect the real situation of SEP flux in interplanetary space. The peak flux of SPE not only depends on the SEP intensity in interplanetary space, but also depends on the shock velocity and the number of seed particles information.

The number of seed particles can be accelerated to energy greater than 10MeV, 30MeV and 100MeV during the interval from 12:00UT to 17:00UT on 2000 July 14 are much more than those during the interval from 12:00UT to 17:00UT on 2003 October 28. For Bastille Day Event, the number of seed particles changes greatly with the distance from the sun while the situation for 2003 October 28 SEP event is almost contrary. The results of this paper reveal that variation for the SPE flux at geostationary orbit can't reflect the variation for the SEP flux in interplanetary space for the particles with energy lower than 30MeV. If we want to know the information of the SEP flux in interplanetary space and the information of shock accelerating particles, we must used the SEP data observed by the satellite in interplanetary space.

References

[1] Reames D V 2001 Astophys. J., 548，L233
[2] Bieber J W, Droge W, Evenson P A, et al. 2002, ApJ, 567, 622B.
[3] Tylka A J, Cohen C M S, Dietrich W F. 2001, ApJ, 558, L59
[4] Maia D, Pick M, Hawkins III S E, et al. Solar Phys. 204, 199
[5] MÄKELÄ Pertti, Torsti Jarmo. 2002, Solar Phys. 204, 215
[6] Raeder J, Wang Y L 2001 Solar Phys. 204 325
[7] Tang Y H, Dai Y 2003 Adv. Space Res. 12, 2609
[8] Le G. M., Han Y. B. Proceedings IAU226 Symposium, Cambridge Press, 2005, 346
[9] Reames D V 1999 Space Science Review, 90, 413
[10]Reames D V 2002 Astophys. J., 571, L63
[11]Kallenrode M-B Current view on impulsive and gradual solar energetic events, J. Phys. G: Nucl. Part.e Phys, 2003(9): 965-981
[12]Cane H V et al. 2003 Geophys. Res. Lett. SEP5
[13]Kahler S W 2001 J. Geophys., Res. 106, 20947
[14]Gopalswamy N, Yashiro S, Krucker S, et al. Proceedings IAU226 Symposium, 2004 Sep. Beijing, China (in press)
[15]Gopalswamy N, Yashiro S, Michalek G, et al. 2002 ApJ Letter. 572 L103
[16]http://cdaweb.gsfc.nasa.gov/cdaweb/sp_phys/
[17]http://cdaw.gsfc.nasa.gov/CME_list/UNIVERSAL/2000_07/yht/20000714.105407.w360h.v1674.p273s.yht
[18]http://cdaw.gsfc.nasa.gov/CME_list/UNIVERSAL/2003_10/yht/20031028.113005.w360h.v2459.p015s.yht
[19] Skoug R M, Gosling J T, Steinberg J T, et al. 2004 J. Geophys., Res. 109, A09102